

## 1. Introduction -- Adjusted Virginia Event-Mean-Concentrations

The Center for Watershed Protection (CWP) analyzed the National Stormwater Quality Database (NSQD) version 1.1 to compare Virginia and National Event Mean Concentrations (EMCs) derived for total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS). Statistical trends were examined for the EMCs based on land use (residential/non-residential) and physiographic province (Piedmont/Coastal Plain). Table 1 provides the EMCs for Virginia, as well as the National EMCs for comparison. The following sections discuss the methods and implications of this analysis, as well as recommended EMCs for inclusion in Virginia's stormwater management program.

Table 1. National vs Virginia Event Mean Concentrations	
Parameter	Median EMC (mg/L)
<b>Total Nitrogen</b>	
National	1.9
Virginia	1.86
<i>Residential</i>	2.67
<i>Non-Residential</i>	1.12
Virginia Coastal Plain	2.13
<i>Residential</i>	2.96
<i>Non-Residential</i>	1.08
Virginia Piedmont	1.70
<i>Residential</i>	1.87
<i>Non-Residential</i>	1.30
<b>Total Phosphorus</b>	
National	0.27
Virginia	0.26
<i>Residential</i>	0.28
<i>Non-Residential</i>	0.23
Virginia Coastal Plain	0.27
Virginia Piedmont	0.22
<b>Total Suspended Solids</b>	
National	62
Virginia	40

## 2. EMC Statistical Analysis

Virginia entries were separated from the NSQD and compared to the remaining entries in the database (NSQD – VA data). A significant percentage (approximately 22%) of the NSQD sites are located within Virginia, supporting the feasibility of the statistical comparison. The number of entries used in the statistical analysis is summarized in Table 2. A list of Virginia jurisdictions where NSQD data was available and utilized is included in Table 3. The following criteria were used to determine the entries included in the analysis:

- All sites that contained best treatment practices (BMPs) within their drainage areas were excluded from the analysis to obtain EMCs for untreated stormwater.

## Appendix A: Virginia EMCs & Land Use Loading Rates

- Only observations above the detection limit for each pollutant were included.
- All sites located east of I-95 were considered coastal plain and sites located west of I-95 were considered Piedmont.

<b>Table 2. Number of NSQD Entries</b>		
	<b>Virginia</b>	<b>National (NSQD – VA entries)</b>
# Total Individual Sites	78	282
# Sites with BMP Treatment	11	3
# Sites included in the Analysis	67	279
# Observations Included in the Analysis	753	2834
	<b>Piedmont</b>	<b>Coastal Plain</b>
# VA Sites Included in the Analysis	23	44
# VA Observations Included in the Analysis	150	603

<b>Table 3. Virginia Jurisdictions with in the NSQD</b>	
<b>Jurisdiction</b>	<b># Sites</b>
Arlington	2
Chesapeake	7
Chesterfield County	9
Fairfax County	6
Hampton	7
Henrico County	6
Newport News	7
Norfolk	9
Portsmouth	5
Virginia Beach	9

Two statistical tests were used to determine if the Virginia EMCs were significantly different from National EMCs; Mann-Whitney (two-tailed) and one-way ANOVA statistical tests. The ANOVA was available from the Analysis Tools Add-In for Excel and the Mann-Whitney was set up as a spreadsheet in Excel. For both tests, p-values < 0.05 indicate that the samples are statistically different at the 95% or greater confidence level. P-values for the Mann-Whitney test are generally obtained from a critical values table for the test when the sample sizes are less than 20. However, sample sizes exceeded 20 for all of the EMC comparisons conducted as part of this analysis. For these large sample sizes, the Mann-Whitney was approximated by a normal distribution (z) and the p-value was obtained from a standard normal curve area table. The results of the Mann-Whitney and ANOVA are provided in Tables 4, 5, and 6, and the calculations are provided in Appendix A. Land use included in this analysis included

## Appendix A: Virginia EMCs & Land Use Loading Rates

residential, non-residential (institutional, commercial, industrial, and freeway), and open space. Entries from mixed land use classifications were categorized according to the highest percentage land use in the drainage area.

Table 4. VA Comparison to National Data					
Parameter	Mann-Whitney p-value	ANOVA p-value	Significant Difference Between VA and National Data	# VA Samples	# National Samples
TN	0.0366	0.000289	yes	664	2463
TP	0.2302	0.00262	ANOVA: yes Mann-Whitney: no	651	2368
TSS	<4E-04*	2.87E-17	yes	662	2603
Residential TN	<4E-04*	0.004514	yes	363	1002
Residential TP	0.002	0.000124	yes	399	967
Residential TSS	<4E-04*	2.88E-10	yes	400	1070
Non-Residential TN	<4E-04*	9.30E-22	yes	288	1277
Non-Residential TP	0.9204	0.464218	no	247	1221
Non-Residential TSS	<4E-04*	3.20E-07	yes	256	1347
Open Space TN	<4E-04*	0.454971	ANOVA: no Mann-Whitney: yes	13	184
Open Space TP	0.1616	0.62312	no	5	180
Open Space TSS	0.009	0.164779	ANOVA: no Mann-Whitney: yes	6	186

\*Approximated from the highest value ( $z = 3.49$ ) in a standard normal curve area table

Table 5. VA Land Use Comparison					
Parameter	Mann-Whitney p-value	ANOVA p-value	Significant Difference Between Land Use Data	# Residential Samples	# Commercial Samples
Residential/Non-Residential TN	4E-04*	3.73E-75	yes	363	288
Residential/Non-Residential TP	0.0238	0.295137	ANOVA: no Mann-Whitney: yes	399	247
Residential/Non-Residential TSS	0.61	0.733315	no	400	256
				# Residential Samples	# Open Space Samples
Residential/Open Space TN	4E-04*	9.59E-04	yes	363	13
Residential/Open Space TP	0.0702	0.175480	no	399	5
Residential/Open Space TSS	0.1096	0.338883	no	400	6
				# Commercial Samples	# Open Space Samples
Non-Residential/Open Space TN	4E-04*	2.15E-08	yes	288	13
Non-Residential/Open Space TP	0.1528	0.465171	no	247	5
Non-Residential/Open Space TSS	0.1528	0.246322	no	256	6

\*Approximated from the highest value ( $z = 3.49$ ) in a standard normal curve area table

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Table 6. VA Coastal Plain / Piedmont Comparison					
Parameter	Mann Whitney p value	ANOVA p-value	Significant Difference Between Coastal Plain and Piedmont Data	# VA Coastal Plain Samples	# VA Piedmont Samples
TN	<4E-04*	7.06E-09	yes	538	126
TP	0.0024	0.100758	ANOVA: no Mann Whitney: yes	522	129
TSS	0.0048	0.670342	ANOVA: no Mann Whitney: yes	531	131
<b>Coastal Plain</b>				<b># Residential Samples</b>	<b># Non-Residential Samples</b>
Residential/Non-Residential TN	<4E-04*	5.35E-73	yes	298	235
Residential/Non-Residential TP	0.0308	0.166395	ANOVA: no Mann Whitney: yes	324	198
<b>Piedmont</b>					
Residential/Non-Residential TN	<4E-04*	2.10E-22	yes	65	53
Residential/Non-Residential TP	0.6818	0.435501	no	75	49

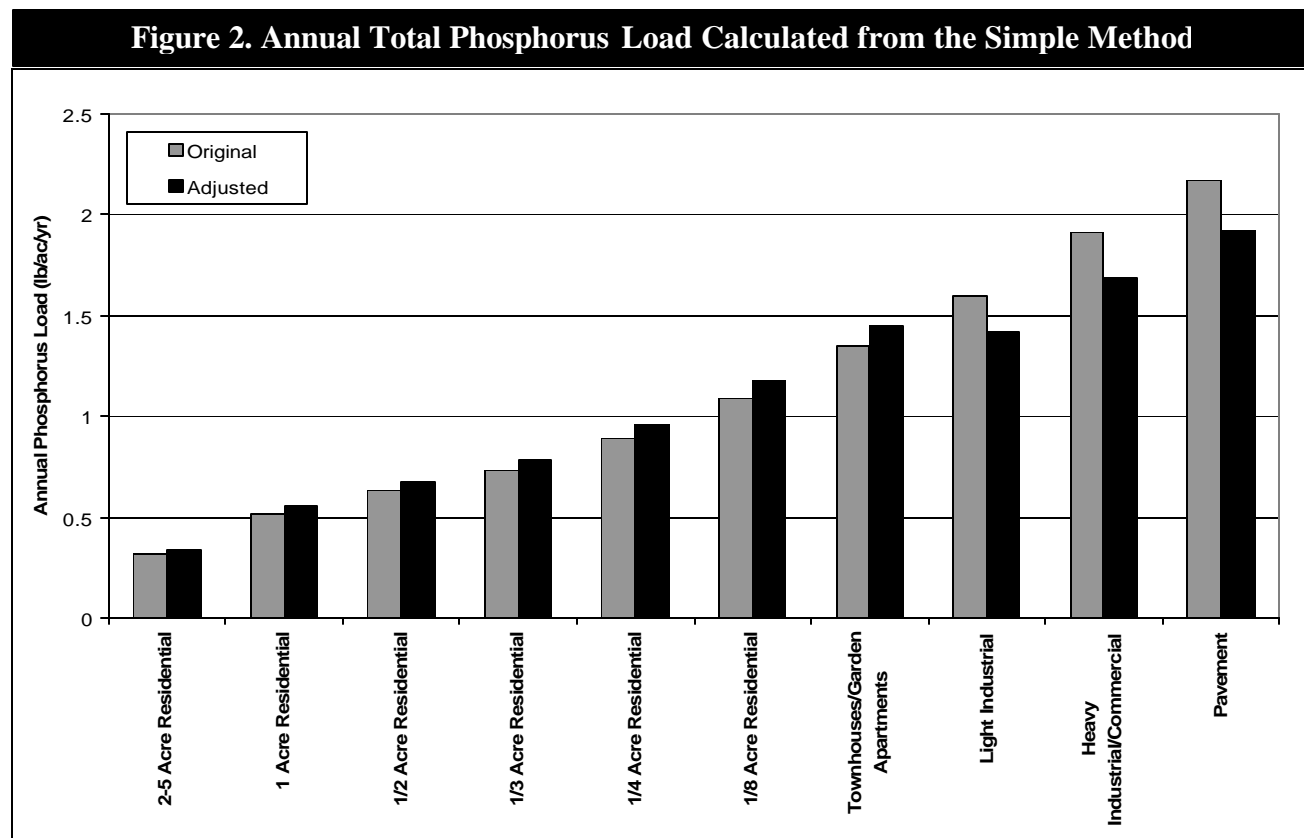
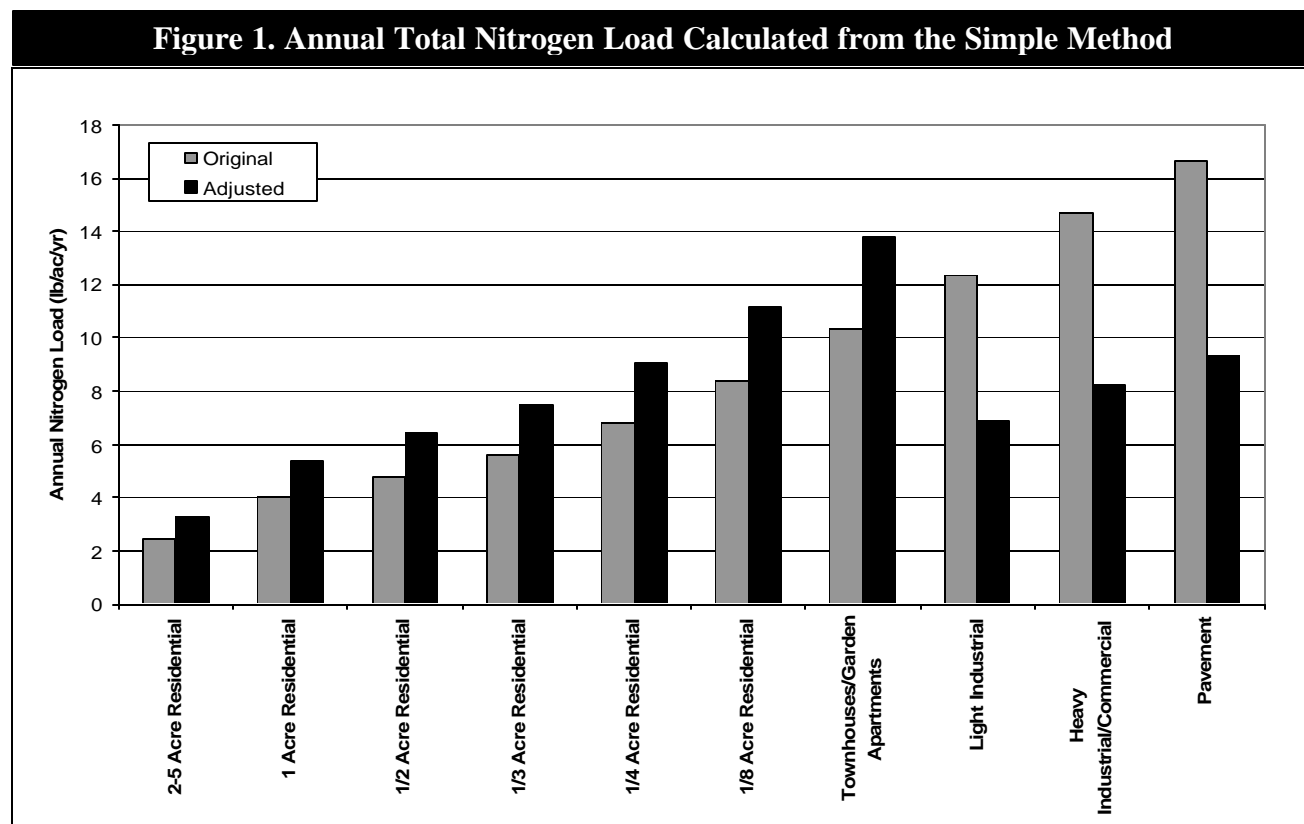
\*Approximated from the highest value ( $z = 3.49$ ) in a standard normal curve area table

The results show a significant difference between Virginia EMCs and National EMCs. Appendix B contains the median EMCs for all sample categories included in the statistical analysis. From the analysis, the following observations were made:

- VA has lower median EMCs for TN, TP, and TSS than the national data.
- Within VA, residential areas contain higher median TN, TP, and TSS EMCs than non-residential areas. Analysis of open space areas was disregarded due to limited data available in those locations.
- Within VA, the Coastal Plain contains higher median TN, TP, and TSS EMCs than the Piedmont physiographic region.
- TN- The following EMCs are significantly different within VA: residential/non-residential; Coastal Plain/Piedmont; Coastal Plain residential/non-residential; and Piedmont residential/non-residential.
- TP- The following EMCs are significantly different within VA: residential/non-residential; and Coastal Plain/Piedmont.
- TSS- While VA has lower median TN, TP, and TSS EMCs than the National median EMCs; no difference exists between residential/non-residential areas or Coastal Plain/Piedmont regions within the state. It is important to keep in mind that stream bank erosion is the main component of TSS within streams/rivers, as opposed to input from stormwater runoff.

### 3. Land Use loading Rates

The adjusted EMCs for Virginia were used to update previous land use loading rates (pounds/acre/year). Previous land use loading rates (Table 5-15 from the Virginia Stormwater Management Handbook) are presented in Appendix C, as well as updated rates based on the adjusted EMCs. The loading rates were computed using the Simple Method computation for Virginia by using residential and non-residential EMCs. Figures 1 and 2 show the original loading rates, as well as the adjusted loading rates for TN and TP.



#### 4. Conclusions and Recommendation

Based on the statistical analysis, the options listed below for TN and TP are available for adjusting Virginia EMCs. As was previously mentioned, open space was not included in these recommendations due to the limited amount of data available for the statistical analysis. TSS was also disregarded because input from stormwater runoff is minimal in comparison to streambank erosion.

In Virginia, there is a statistically significant difference between residential and non-residential sites, particularly for TN. This provides justification for using different EMCs for the two categories of land use. Since the EMC for non-residential is lower, it also means that commercial sites have somewhat of a compliance “handicap,” which is balanced by their generally higher levels of impervious cover.

##### **Total Nitrogen**

Option 1: Virginia Residential and Non-Residential EMCs – National EMCs were not considered an option based on the statistical analysis results that Virginia TN EMCs are significantly different than the National TN EMCs.

Option 2: Virginia Coastal Plain/Piedmont Residential and Non-Residential EMCs – While this option is statistically supported, it results in four EMC options and may be too complicated for utilization. The Piedmont also results in a lower standard and there may be equity problems with having Piedmont and Coastal Plain sites achieve different standards. Finally, since there is no data from the “mountain” physiographic provinces, there is no basis to recommend an EMC for those areas other than the State-wide numbers.

##### **Total Phosphorus**

Option 1: National EMC

Option 2: Virginia EMC

Option 3: Virginia Residential and Non-Residential – The national data provides justification that residential TP is greater than non-residential TP. This option would provide an incentive for compliance.

The recommended approach is to use Virginia residential and non-residential EMCs for both TN and TP due to the feasibility of implementation and the supporting data in the analysis.